DELAWARE RIVER BASIN
SANDSPRING CREEK
PENNSYLVANIA

NDI ID PA 00640
PA DER 45-120

LEVEL
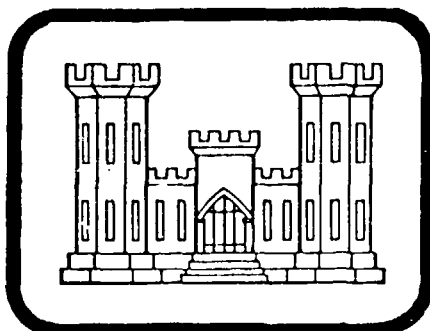
LAKE AKIBA DAM

DTIC

OWNED BY

CAMP AKIBA

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

$PACW31-81-C-0016$

PREPARED FOR
DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT CORPS OF ENGINEERS

BALTIMORE, MARYLAND
21203

BY

O'BRIEN & GERE

PHILADELPHIA, PENNSYLVANIA
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AUGUST 1981
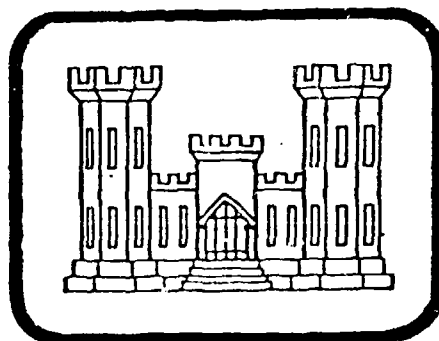
DELAWARE RIVER BASIN

LAKE AKIBA DAM
PENNSYLVANIA

NDI ID PA-00640

OWNED BY
CAMP AKIBA

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

Prepared for:

DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

Prepared by:

O'BRIEN & GERE ENGINEERS, INC.
1617 J F Kennedy Boulevard - Suite 1760
Philadelphia, Pennsylvania 19103 .

August 1981

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected, and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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PHASE I REPORT

NATIONAL DAM INSPECTION PROGRAM

Name of Dam: Lake Akiba Dam
State: Pennsylvania
County: Monroe
Stream: Sandspring Creek
Coordinates: N40^{o}59.3', W75^{o}21.3'
Dates of Inspections: May 20, 1981 & June 1, 1981

ASSESSMENT

Lake Akiba Dam is a 360-foot long, 22-foot high earth embankment dam, constructed in 1926 to provide a lake for recreational use. The maximum storage capacity of Lake Akiba is 280 acre-feet. The dam has a crest width of approximately seven feet and side slopes both upstream and downstream which average 2H:1V. According to design drawings of the dam, a concrete core wall was constructed in a 5-foot wide cutoff trench and extended to the dam crest, where it is two feet wide. The principal spillway consists of a 50-foot long concrete Ogee section. It is located at the eastern dam abutment. A 30-inch diameter low level outlet is located approximately 70 feet east of the western abutment.

Lake Akiba Dam is classified as a "Small" size, "High" hazard dam. The recommended spillway design flood (SDF) for a dam in this classification ranges from one-half of the Probable Maximum Flood (PMF) to the full PMF. Because the dam is relatively low and has a maximum storage capacity of 280 acre-feet, the selected SDF is one-half of the PMF. The spillway is capable of passing about 26 percent of the PMF prior to overtopping of the dam; therefore, the spillway is classified as "Seriously Inadequate". The dam is classified as "Unsafe, Non-Emergency" because failure of the dam will probably occur for less than 50 percent of the PMF.

Based upon the visual inspection of the dam and review of the information provided by the Pennsylvania Department of Environmental Resources (DER), the Lake Akiba Dam is considered to be in fair condition. The spillway, however, is in poor condition and should be investigated immediately.

Recommendations and Remedial Measures

The following recommendations and remedial measures should be initiated immediately.

    a.   Facilities.

The Owner should retain the services of a licensed professional engineer, experienced in the design and construction of dams, to assist in the implementation of the following recommendations:

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1.   Detailed hydrologic and hydraulic analyses should be performed to evaluate the discharge capacity of the spillway. Pending the results of the analyses, measures should be taken to repair and/or replace the existing spillway.

2.   An investigation should be made to assess the source and extent of the seepage observed at the downstream toe of the dam.

The Owner should initiate the following remedial measures:

1.   The embankment should be cleared of all trees and brush. The resulting voids should be backfilled with suitable material and thoroughly compacted to ensure proper density.

2.   Animal burrows in the downstream embankment face should also be filled with suitable material and thoroughly compacted to ensure proper density.

3.   Slope protection should be provided on the upstream face of the dam.

4.   The layout of the outlet works should be verified and the assumed mid-level intake valve should be provided with a hand wheel operator.

5.   A grass cover should be established and maintained on the slopes of the dam.

6.   Adequate erosion protection should be provided at the discharge end of the low level outlet.

7.   Debris and growth in the spillway discharge should be removed.

b.   Operation and Maintenance Procedures

1.   An operation and maintenance program should be developed and implemented. This program should include periodic operation of the outlet works, routine maintenance tasks, and an annual technical inspection performed by a licensed professional engineer, experienced in the design and construction of dams.

2.   A formal surveillance and downstream warning plan should be developed and implemented, during periods of extreme rainfall, to ensure that downstream residents and the appropriate agencies are notified in the case of an impending dam failure.

O'BRIEN & GERE ENGINEERS, INC.

John J. Williams, P.E.
Vice President
Pennsylvania Registration No. PE0049?0E

Approved by: _____   Date: 3/ Aug 81

JAMES W. Peck
Colonel, Corps of Engineers
District Engineer

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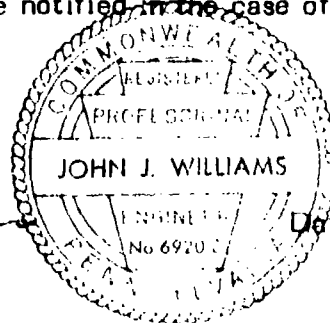
UPSTREAM OVERVIEW FROM THE RIGHT ABUTMENT. (5/20/81)

OVERVIEW FROM THE LEFT ABUTMENT WITH SPILLWAY IN THE FOREGROUND. (5/20/81)

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PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM
LAKE AKIBA DAM
NDI ID PA-00640
PA DER 45-120

SECTION 1

PROJECT INFORMATION

1.1   General

a.   Authority. The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

b.   Purpose. The purpose of this inspection is to determine if Lake Akiba Dam constitutes a hazard to human life and property.

1.2   Description of Project (Based upon information obtained from the Pennsylvania Department of Environmental Resources (DER), Division of Dam Safety, Harrisburg, PA., Mr. Howard Batterman, Camp Akiba Director, Mr. Wright Bond, caretaker of the camp, and from the field inspection.)

a.   Dam and Appurtenances. Lake Akiba Dam is a 360-foot long, 22-foot high earth embankment dam, constructed for recreational purposes in 1926. The dam has a crest width of approximately 7 feet and side slopes averaging 2H:1V. According to design drawings of the dam, a concrete corewall was constructed in a 5-foot deep by 5-foot wide cutoff trench and extended to the crest of the dam, where it is two feet wide.

A 50-foot long concrete Ogee spillway is located at the eastern dam abutment. Its crest is approximately four feet below the top of the dam, except for a 3-inch deep, 9-foot wide notch at the center of the spillway. A spillway discharge apron extends for approximately 100 feet in a southwesterly direction, at about a 50-degree angle to the axis of the dam. The apron is approximately 40 feet wide and has 4-foot high concrete training walls. According to design drawings of the dam, concrete keywalls were constructed just upstream and downstream of the Ogee section and the discharge apron was provided with a grouted riprap surface. The downstream edge of the discharge apron drops approximately three feet to the discharge channel.

The outlet works consist of: 1) a gated 12-inch diameter pipe extending through the concrete Ogee section; and 2) a 30-inch diameter concrete low level outlet pipe located approximately 70 feet east of the western dam abutment. The 12-inch diameter outlet at the spillway was not part of the original construction of the dam. It is believed to have been installed to help maintain a base flow in Sandspring Creek. The 30-inch diameter outlet pipe was part of the original construction, but it was provided with a new upstream control system around 1962. This system consists of 12-inch diameter low and mid-level intakes.

b.   **Location.**   Lake Akiba Dam is located on Sandspring Creek in the Jackson Township, Monroe County, Pennsylvania.   To illustrate the location, portions of the USGS Quadrangles entitled "Saylorsburg, PA.", "Brodheadsville, PA.", "Mount Pocono, PA." and "Pocono Pines, PA.", have been incorporated and included as Figure 1 of Appendix E. USGS reference coordinates for this dam are N 40° 59.3' and W 75° 21.3'.

c.   **Size Classification.** Lake Akiba Dam has a maximum storage capacity of 280 acre-feet and a maximum height of 22 feet. The dam is, therefore, classified as a "Small" size dam (height less than 40 feet and storage less than 1,000 acre-feet).

d.   **Hazard Classification.** Three cabins for Camp Akiba are located 100 to 200 feet downstream of the dam.   The cabins have first floor elevations approximately three feet above the stream and provide housing for as many as 80 people during the camping season. It is probable that a dam failure would cause excessive property damage and the loss of more than a few lives. Therefore, the Lake Akiba Dam is classified as a "High" hazard structure.

e.   **Ownership.** The dam is owned by Camp Akiba, Reeders, PA. 18352. The current Camp Director is Mr. Howard Batterman, who may be reached at the following number: 717-629-0863. The Philadelphia area office for the camp is located in Bala Cynwyd, PA. (215/649-7877).

f.   **Purpose of Dam.**   The dam was constructed to provide a lake for recreational activities associated with Camp Akiba.

g.   **Design and Construction History.** The dam was designed in 1926 by Mr. John F. Seem, C.E., of Tannersville, PA. The structure was built during the same year.   Other than photographs of the original construction, provided by the Pennsylvania DER, no original construction information is available.

About 1962, a new outlet control system was constructed.   No plans are available relative to the installation of two 12-inch diameter intakes, which were installed at different elevations along the upstream face of the dam. A new gate chamber, located just upstream of the dam crest, was built to provide access to the 12-inch diameter gate valves on the new intakes.

h.   **Normal Operating Procedures.** Under normal conditions, facilities at the dam do not require operation. According to Mr. Wright Bond, caretaker of the camp, the outlet works were last operated 2 or 3 years ago and they are believed to still be operable.   The assumed low level outlet valve was opened during the inspection, but the other valve could not be checked since it was not provided with an operating mechanism.

1.3   Pertintent Data

a.   Drainage Area.

Square Miles   3.4

b.   Discharge at Dam Site. (cfs)

Spillway (Water Surface at top of dam elevation 946.0)   1,320
Outlet Works (Water Surface at normal pool elevation 942.0)   21

c.   Elevation. (MSL)

Top of Dam   946.0
Spillway Crest   942.0
Outlet Works (Inlet Inverts)   Unknown
Outlet Works (Outlet Invert) $\pm$ 924.0
Streambed at Toe of Dam $\pm$ 924.0

d.   Reservoir Length. (Feet)

Normal Pool, El. 942   1,600
Maximum Non-overtopping pool, El. 946   1,900

e.   Storage. (Acre-Feet)

Normal Pool, El. 942   126
Top of Dam, El. 946   280

f.   Reservoir Surface Area. (Acres)

Normal Pool, El. 942   27
Top of Dam, El. 946   39

g.   Dam Data.

Type	Earth Embankment
Length	360 Feet
Height	22 Feet
Crest Width	7 Feet
Side Slopes (Upstream)	2H:1V
(Downstream)	2H:1V
Zoning	None, homogeneous gravelly clay embankment
Impervious Core	Concrete Corewall to crest of dam
Cutoff	5-foot deep trench filled which concrete
Grout Curtain	NA

h.   Diversion System.

None

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i.   Spillway Data.

Type   Concrete Ogee
Length   50 Feet
Crest Elevation   942.0
Gates   None
Upstream Channel   NA
Downstream Channel   40-foot wide discharge chute
                         approximately 100 feet long.

j.   Outlet Works.

Reservoir Drains   1. Two, 12-inch diameter pipes with
                         valves empty into one 30-inch diam-
                         eter concrete pipe which outlets at
                         the downstream toe of the dam at
                         approximately Elev. 924.

                         2. One, 12-inch diameter gate valve
                         and pipe which passes through the
                         Ogee spillway at approximately
                         El. 940.5.

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SECTION 2

ENGINEERING DATA

2.1 Design

a. **Data Available.** Miscellaneous correspondence, memoranda and permit information were provided by the Pennsylvania DER in Harrisburg, Pennsylvania. The following drawings for Lake Akiba Dam were also provided by the Pennsylvania DER:

1. Flow Line Plan: Lake Akiba Dam
2. Location Plan
3. General Plan
4. Cross Sections A-B and C-D
5. Longitudinal Section

b. **Design Features.** The design features of the dam are described in Section 1.2a and shown on the design drawings included in Appendix E.

2.2 Construction

Based upon the field inspection, it appears that the dam was constructed in conformance with the design drawings. No specifications, materials analyses or other construction information is available.

2.3 Operation

Operation of the outlet works is necessary only when it is desired to lower the level of Lake Akiba. The low level outlet valve may be operated by opening a vault access cover on the crest of the dam, descending a few vault steps and turning a handwheel operator. Mr. Wright Bond, caretaker of the camp, has the key to unlock the padlock on the vault access cover. No handwheel has been provided on the assumed mid-level outlet.

2.4 Evaluation

a. **Availability.** The engineering information presented in this report was obtained from the Pennsylvania DER in Harrisburg, Pennsylvania.

b. **Adequacy.** The information obtained from the Pennsylvania DER, along with that obtained from the Owner's representatives and the field inspection , has been adequate for a Phase I evaluation.

c. **Validity.** The information appears to be valid, since no discrepancies between the field measurements and those presented on the drawings were found.

SECTION 3

VISUAL INSPECTION

3.1 Findings

a.   General.   The Lake Akiba Dam was inspected on May 20, 1981 and June 1, 1981. At the time of the inspections, the water surface elevation of Lake Akiba was slightly above the crest of the spillway, El. 942.0. Underwater areas were not inspected.   The observations and comments of the field inspection team are presented in Appendix A of this report.

b.   Dam.   The dam appears to be in fair overall condition.   Although the entire dam is overgrown with trees, the dam has satisfactory horizontal and vertical alignment.   The concrete core wall extends approximately 3 inches above the earth portion of the dam crest and it appears to be sound.

Deficiencies were observed during the field investigation on the upstream face which is constructed on a slope estimated to be 2H:1V. Riprap has been displaced and erosion has occurred at a few locations.   Wave action and pedestrian traffic appear to be responsible for these conditions.

The downstream slope of the dam is also approximately 2H:1V.   Much of the original stone facing has slid to the toe of the slope.   Several trees, some with trunks up to 16 inches in diameter, were observed.   Many depressions were in evidence over the entire downstream face. An animal burrow was observed near the center of the dam, toward mid-height on the downstream slope.

Seepage was found at two locations to the east of the outlet works (See sheet 11A of Appendix A).   It was estimated to be approximately one gallon per minute at the western most location and no flow was observed at the other location (Photo 8, Appendix C).

c.   Appurtenant Structures.   A 50-foot long concrete Ogee spillway is located at the eastern dam abutment.   The following deficiencies were observed in the spillway: 1) The eastern spillway abutment wall is seriously undermined, deteriorated, and on the verge of collapse (Photos 5 & 6, Appendix C); 2) The eastern spillway training wall has collapsed (Photo 10, Appendix C); 3) The eastern portion of the spillway is severely spalled; and 4) Extensive vegetative growth is evident in the spillway discharge chute and overhanging the training wall.   In addition, a 12-inch diameter pipe and gate valve were observed in the Ogee spillway about 4 feet from the west end.   According to the Owner's representative, the pipe may have been used to help maintain a base flow in the creek during dry weather periods, but the gate valve on the pipe is no longer operable.

The present arrangement of the outlet works were installed around 1962 and they appear to be in good condition.   An underground gate chamber is located just upstream of the dam crest and houses two 12-inch diameter gate valves.   This is not the optimal location for the valves, because the intake pipes are kept under constant hydrostatic pressure.

During the site inspection, access to the chamber was provided and the assumed low level outlet was operated. The other gate valve did not have a handwheel operator; therefore, it could not be operated.

No riprap, or other means of erosion protection, has been placed at the discharge end of the low level outlet.

d.   Reservoir Area. The reservoir area consists of approximately 3.4 square miles of steep to moderately sloped terrain. Approximately half of the area is forested and there are only a few homes scattered throughout the drainage area. No evidence of excessive siltation or unstable slopes along the perimeter of the lake were observed.

e.   Downstream Channel. The spillway and low level outlet discharge to Sandspring Creek, which conveys flow easterly for approximately one mile prior to merging with Appenzel Creek. Flow along Sandspring Creek is sluggish, since the slope is fairly flat and the stream banks are well-vegetated.

3.2   Evaluation

The dam is considered to be in fair overall condition. However, the spillway is in poor condition and should be investigated immediately.

SECTION 4

OPERATIONAL PROCEDURES

4.1   Procedures

Two 12-inch diameter gate valves of the reservoir drain system are located in an underground vault just upstream of the dam crest, approximately 70 feet east of the western dam abutment.   Access is available through a circular access cover, which is normally kept locked. The gate valve on the assumed low level outlet has been provided with a handwheel operator and was operable at the time of inspection. The gate valve on the assumed mid-level intake was not operated, since it had no operator.   The caretaker of the camp, Mr. Wright Bond, has the key to open the access cover to the vault.

The only other feature of the dam which could be operated is the 12-inch diameter gate valve located about 4 feet from the west end of the spillway with an invert about 1.5 feet below the spillway crest. The valve is believed to have been provided to maintain a base flow in the creek during dry weather periods, but according to Mr. Bond, it is no longer operable.

4.2   Maintenance of the Dam

Maintenance of the dam is minimal, as evidenced by the trees and brush which cover the dam, the numerous riprap slides and the poor condition of the spillway.

4.3   Maintenance of Operating Facilities

According to the Owner's representative, the two 12-inch diameter gate valves of the reservoir drain system were last operated 2 or 3 years ago. He does not recall the 12-inch diameter gate valve in the Ogee spillway as having ever been operable. No routine operation of the valves is performed.

4.4   Description of any Warning Systems in Affect

According to the Owner's representative, no formal surveillance or warning system is currently in effect. However, in the event of an extreme rainfall event, the camp cabins, between 100 and 200 feet downstream of the dam, would be evacuated.

4.5   Evaluation

As indicated in Section 3, the lack of a periodic operation program and a formal maintenance program is reflected by the deteriorated condition of the dam. The deficiencies identified during visual inspection of the dam and appurtenances should be corrected in a timely manner, as discussed in Section 7. Once the improvements are made, a program should be implemented to periodically operate the outlet works, maintain the dam and spillway and to provide for an annual

technical inspection of the dam. In addition, a formal surveillance and downstream warning system should be developed and implemented during periods of extreme rainfall.

SECTION 5

HYDROLOGY AND HYDRAULICS

5.1 Evaluation of Features

a. <u>Design Data</u>. The Lake Akiba Dam has a 3.4 square mile drainage area and a maximum storage capacity of approximately 280 acre feet. The drainage area lies generally to the north of the dam and consists of moderately sloped and forested terrain, ranging from about El. 2080 at the northern most boundary of the drainage area to elevation 942 at normal pool elevation. The area is very sparsely populated and no significant impoundments presently exist upstream of the dam. No original hydrologic or hydraulic calculations are available.

b. <u>Experience Data</u>. No operation and maintenance records for the dam have been kept. According to the Owner's representative, the maximum water surface elevation occurred in 1955, during Hurricane Diane, when flow in the spillway reached a depth of approximately one foot. No rainfall data or upstream gaging station information is available.

c. <u>Visual Observations</u>. The 50-foot long concrete Ogee spillway is located at the eastern dam abutment. The Ogee section and its adjacent abutment walls are seriously deteriorated and in need of repair or replacement. In particular, the east side spillway abutment wall is seriously undermined and on the verge of collapse. Just downstream of this location, the east side training wall for the discharge chute has collapsed. Also, the floor of the discharge chute is overgrown with brush and several trees are overhanging the training walls.

The outlet works are located approximately 70 feet east of the western dam abutment. When the dam was originally constructed, a 30-inch diameter low level outlet was provided. About 1962, a new upstream control system was installed. Plans for this modification are not available; however, according to the Owner's representative 12-inch diameter low and mid-level intake pipes were installed. Access to the underground gate vault was provided. The operability of the assumed low level outlet valve was verified. Operability of the assumed mid-level outlet valve could not be verified because the handwheel operator was not available.

A gated 12-inch diameter pipe passes through the concrete Ogee spillway about 4 feet from the west end of the spillway. According to the Owner's representative, the pipe may have been used to help maintain a base flow in Sandspring Creek during dry weather periods, but its gate valve is no longer operable.

d. <u>Overtopping Potential</u>. The recommended Spillway Design Flood (SDF) for a "Small" size, "High" hazard dam, ranges from one-half of the probable maximum flood (PMF) to the full PMF. Because the maximum available storage for the site is towards the lower end of the range established for "Small" size dams, the selected SDF is one half of the PMF.

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Hydrologic and hydraulic calculations were performed with the assistance of the HEC-1, Dam Safety Version, computer program. Refer to Sheet 2 of Appendix D for a brief description of the program. The SDF was routed through the reservoir with the starting water surface elevation at the spillway crest, Elev. 942.0. The peak design flood inflow to Lake Akiba was computed to be approximately 2,920 cfs. The corresponding peak outflow was computed to be about 2,900 cfs, resulting in a maximum depth of flow over the dam of approximately one foot during the 7-hour period in which overtopping could be expected. The spillway is capable of discharging about 26 percent of the PMF before overtopping of the embankment occurs.

e. Spillway Adequacy. In order to assess the potential for increased damage due to dam failure, the embankment was assumed to breach with water flowing 1.0-foot deep over the top of the dam for a period of one hour. A review of the results of this analysis indicates that the water surface elevation at the three camp cabins 100 to 200 feet downstream of the dam is 1.8 feet higher for the breach condition than for the non-breach condition. Water would be in the cabins to a depth of 3.3 feet for the breach condition. The spillway is classified as "Seriously Inadequate". The dam is classified as "Unsafe, Non-Emergency".

SECTION 6

STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a.   Visual Observations. The dam appears to be stable for static loading conditions.   The horizontal and vertical alignments appear to be satisfactory; however, several conditions exist which could eventually lead to problems: 1) several minor riprap and erosion failures along the upstream face of the dam; 2) the presence of trees over the entire dam; 3) lack of adequate cover or a means of protecting the downstream face of the dam; 4) seepage at the downstream toe; and 5) the absence of riprap, or other means of erosion protection at the discharge end of the low level outlet. (See Section 3 for more detail.)

The Ogee spillway and abutment walls are in poor condition because of severe spalling, cracking and undermining.

b.   Design and Construction Data. Design drawings for the dam were obtained from the Pennsylvania DER in Harrisburg, Pennsylvania, and are included in Appendix E. No original design calculations or construction data are available, according to the Owner's representative.

c.   Operating Records. According to the Owner's representative, no operating records have been maintained for the dam.

d.   Post Construction Changes. A new upstream piping and gating system was installed on the 30-inch diameter low level outlet about 1962. No drawings for the modifications are available; however, the Owner's representative believes that the 12-inch diameter low and mid-level intake pipes and gate valves were put into service at this time. The two 12-inch diameter gate valves are located in a gate chamber just upstream of the dam crest about 70 feet from the western abutment of the dam.

e.   Seismic Stability. Lake Akiba Dam is located in Seismic Zone 1, according to the Seismic Zone Map of Contiguous States. A dam located in Seismic Zone 1 will generally be stable under expected Zone 1 earthquake conditions, if it is stable under static loading conditions.

SECTION 7

ASSESSMENT, RECOMMENDATIONS, AND PROPOSED REMEDIAL MEASURES

7.1 Dam Assessment

a. <u>Evaluation.</u> Visual inspection of Lake Akiba Dam indicates that the dam is in fair overall condition, but the spillway is in poor condition. Several deficiencies have been identified and are discussed in Section 3. The more serious deficiencies include the presence of trees and brush over the entire dam, numerous riprap slides on the upstream and downstream faces of the dam, and the deteriorated condition of the spillway located at the eastern dam abutment. It is important that all the observed deficiencies (discussed in Section 3) be corrected in a timely manner to insure the safety of the dam.

The recommended SDF for a "Small" size, "High" hazard dam ranges from one-half of the PMF to the full PMF. The selected SDF for Lake Akiba Dam is one half of the PMF. Based on a review of the hydrologic/hydraulic analyses, the spillway is capable of passing about 26 percent of the PMF before the embankment would be overtopped. The spillway is classified as "Seriously Inadequate". The dam is classified as "Unsafe, Non-Emergency".

b. <u>Adequacy of Information.</u> The information provided by the Pennsylvania DER, along with that obtained from the visual inspection and subsequent conversations with the Owner's representative, is considered adequate for Phase 1 Evaluation.

c. <u>Urgency.</u> The recommendations and remedial measures discussed in Section 7.2 should be implemented immediately.

d. <u>Necessity for Further Investigation.</u> Further investigations should be implemented as discussed in Section 7.2.

7.2 Recommendations and Remedial Measures

The following recommendations and remedial measures should be initiated immediately.

a. <u>Facilities.</u>

The Owner should retain the services of a licensed professional engineer, experienced in the design and construction of dams, to assist in the implementation of the following recommendations:

1. Detailed hydrologic and hydraulic analyses should be performed to evaluate the discharge capacity of the spillway. Pending the results of the analyses, measures should be taken to repair and/or replace the existing spillway.

2.   An investigation should be made to assess the source and extent of the seepage observed at the downstream toe of the dam.

The Owner should initiate the following remedial measures:

1. The embankment should be cleared of all trees and brush. The resulting voids should be backfilled with suitable material and thoroughly compacted to ensure proper density.

2. Animal burrows in the downstream embankment face should also be filled with suitable material and thoroughly compacted to ensure proper density.

3. Slope protection should be provided on the upstream face of the dam.

4. The layout of the outlet works should be verified and the assumed mid-level intake valve should be provided with a hand wheel operator.

5. A grass cover should be established and maintained on the slopes of the dam.

6. Adequate erosion protection should be provided at the discharge end of the low level outlet.

7. Debris and growth in the spillway discharge should be removed.

b. Operation and Maintenance Procedures

1. An operation and maintenance program should be developed and implemented. This program should include periodic operation of the outlet works, routine maintenance tasks, and an annual technical inspection performed by a licensed professional engineer, experienced in the design and construction of dams.

2. A formal surveillance and downstream warning plan should be developed and implemented, during periods of extreme rainfall, to ensure that downstream residents and the appropriate agencies are notified in the case of an impending dam failure.

APPENDIX A

INSPECTION CHECKLIST

CHECK LIST
VISUAL INSPECTION
PHASE 1

Name Dam __Lake Akiba Dam__   County __Monroe__   State __PA__   :0110 # __PA-00640__

National)

Type of Dam __Earth Embankment__   Hazard Category __High__

Date(s) Inspection __May 20, 1981__ Weather __clear__   Temperature __65 degrees__
__& June 1, 1981__   (May 20, 1981)   (May 20, 1981)

Pool Elevation at Time of Inspection __942.0__ M.S.L.   Tailwater at Time of Inspection __± 924__ M.S.L.

Inspection Personnel:

__Leonard Beck__   __Alan Hanscom__   __John Rauschkolb__

__Lee DeHeer (6/1/81)__   __Alan Hanscom__   __Recorder__

Remarks:

Mr. Howard Batterman, Camp Akiba Director, and Mr. Wright Bond, Caretaker of the Dam, were

present during the inspection on May 20, 1981.

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	Not applicable.	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	Not applicable.	
DRAINS	Not applicable.	
WATER PASSAGES	Not applicable.	
FOUNDATION	Not applicable.	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	Not applicable.	
STRUCTURAL CRACKING	Not applicable.	
VERTICAL AND HORIZONTAL ALIGNMENT	Not applicable.	
MONOLITH JOINTS	Not applicable.	
CONSTRUCTION JOINTS	Not applicable.	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None observed.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	No significant signs of movement or cracking were observed in the vicinity of the toe of the dam.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Sloughing and erosion are evident on the u/s slope (see Photo 2, Appendix C). Stone on d/s slope has displaced to toe in several locations. Gravel path on crest.	Fill, regrade and reseed eroded areas on u/s slope. Provide more gentle d/s slope or provide adequate vegetative cover.
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	No misalignment observed. Crest of core wall is of a consistent elevation. No significant settlement of the embankment was observed.	
RIPRAP FAILURES	Several areas of displaced riprap were observed on u/s dam face. Also, much of the riprap on the d/s face has slid down the slope.	Replace and supplement existing riprap. Stablize d/s slope.

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MISCELLANEOUS	Trees and brush cover the entire dam. Most trees are deciduous, some up to 16" in diameter. (Photo 1) Animal burrow on d/s face.	Entire dam should be cleared of trees and brush. Fill burrow with appropriate material, compact, and reseed.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	East side abutment wall of spillway is undermined and has started to collapse. (Photos 5 & 6) West side dam abutment appears to be sound.	Spillway wall should be replaced.
ANY NOTICEABLE SEEPAGE	Seepage was observed in two locations along the d/s toe of the dam: 1) near center of dam (1± gpm); and 2) just to the east of the center of the dam (no flow, very wet and spongy). (Photo 8)	Seepage not considered too serious at this time.
STAFF GAGE AND RECORDER	None	
DRAINS	No toe drains. 30-inch diameter low level outlet appears to be in good condition.	Operate the intake valves periodically.

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	30-inch diameter concrete pipe appears to be in good condition.	
INTAKE STRUCTURE	No intake structure has been provided. A gate chamber toward the u/s end of the outlet pipe houses (2) 12-inch gate valves and is in good condition.	
OUTLET STRUCTURE	No outlet structure has been provided. As illustrated on Photo 9 of Appendix C, outlet of pipe has arch-shaped headwall.	
OUTLET CHANNEL	Stagnant pool approximately one foot deep, is located at outlet (Photo 9). Downstream channel is in fair condition.	Consideration should be given to providing protection against erosion at the outlet of the 30-inch pipe.
EMERGENCY GATE	Two (2) 12-inch gate valves were installed circa 1962. Operation of the assumed low level outlet was verified during the inspection.	Provide handwheel operator for assumed mid-level intake valve.

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Severe cracking and spalling of the concrete Ogee section was observed, particularly at west side of spillway. (Photo 7)	Repair or replace spillway.
	East side spillway wall is seriously undermined, deteriorated and near collapse. (Photos 5 & 6)	Replace east side abutment wall.
APPROACH CHANNEL	Short, sloping approach apron appears to be in good condition. (Submerged at time of inspection).	
DISCHARGE CHANNEL	Channel sidewalls are overgrown and in poor structural condition. Much growth observed in channel. East side wall has collapsed. (Photos 4, 7, 10 and 11)	Replace sidewalls of channel. Clear invert of growth and miscellaneous debris.
BRIDGE AND PIERS	Walkway over the spillway is in fair condition.	Top boards will require replacement within a year or two.

GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	Not applicable.	
APPROACH CHANNEL	Not applicable.	
DISCHARGE CHANNEL	Not applicable.	
BRIDGE AND PIERS	Not applicable.	
GATES AND OPERATION EQUIPMENT	Not applicable.	

INSTRUMENTATION

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	Not applicable.	
OBSERVATION WELLS	Not applicable.	
WEIRS	Not applicable.	
PIEZOMETERS	Not applicable.	
OTHER	Not applicable.	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS Sheet 10 of 11
SLOPES	Moderately sloped, forested terrain surrounds the lake.	
	Trees are primarily deciduous.	
	No excessive erosion of slopes was observed.	
SEDIMENTATION	No indication of excessive sedimentation was observed or mentioned by the Owner's representative.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Slight to moderate growth in downstream channel. Good slope. (Photo 11)	
SLOPES	Side slopes are well-vegetated (Photo 11) and reasonably flat.	
APPROXIMATE NO. OF HOMES AND POPULATION	Three cabins just downstream of the dam could be affected by a failure of the dam. During the summer season, these cabins could house between 40 and 80 people. Further downstream, there is a single residence located only a foot or two above the streambed (Photo 12).	

LOCATION PLAN OF DEFICIENCIES

OBSERVED DURING VISUAL INSPECTION

Impoundment

Trees & brush cover entire dam

Suspected low & mid level intakes

Location of auxiliary spillway

Erosion & displaced riprap (typical)

30" Dia. Low Level Outlet

animal burrow

Stones on d/s face have slid to toe of dam (typical)

Severe Spalling

Concrete Ogee Spillway

Flow

Spillway Chute

Seepage Locations

Undermining of side wall

Growth & debris in Spillway Channel

Collapsed Side wall

SUBJECT	SHEET	BY	DATE	JOB NO
Lake Akiba Dam	IIA	ADH	6/16/81	1641.014

SUBJECT	SHEET	BY	DATE	JOB NO
Profile: Lake Akiba Dam	11B	ADH	6-16-81	1841.014

LAKE AKIBA DAM : PROFILE

OF DAM CREST

NOTES:

1.) Steps and access bridge over spillway have been omitted for clarity. (See Photo of left abutment, P. iv)

2.) 12-inch outlet pipe through spillway not shown. (Inv. = 940.6)

APPENDIX B

CHECKLIST
ENGINEERING DATA

NAME OF DAM Lake Akiba Dam

NDI ID # PA-00640

Sheet 1 of 4

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

ITEM	REMARKS
AS-BUILT DRAWINGS	None were prepared.
REGIONAL VICINITY MAP	See Figure 1, Appendix E.
CONSTRUCTION HISTORY	The dam was designed by Mr. John F. Seem, C.E. of Tannersville, PA. and constructed by personnel from the Camp Company, Inc. in 1926.
TYPICAL SECTIONS OF DAM	See design drawings in Appendix E.
OUTLETS - PLAN	See design drawings in Appendix E.
DETAILS	
CONSTRAINTS	
DISCHARGE RATINGS	None available.
RAINFALL/RESERVOIR RECORDS	None available.

ITEM	REMARKS
DESIGN REPORTS	None available.
GEOLOGY REPORTS	None available, except as indicated on the longitudinal section included in Appendix E.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None available.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	See "Longitudinal Section" in Appendix E.
POST-CONSTRUCTION SURVEYS OF DAM	None available.
BORROW SOURCES	lake bottom; primarily a gravelly clay type soil, according to design drawings.

ITEM	REMARKS
MONITORING SYSTEMS	None
MODIFICATIONS	Two 12-inch gate valves, presumably with low and mid-level intakes, were installed on the 30-inch low level outlet circa 1962. No drawings of the construction are available.
HIGH POOL RECORDS	None available. According to Mr. Bond, the highest level occurred during Hurricane Diane in 1955, when the spillway was overtopped by more than a foot.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None
MAINTENANCE OPERATION RECORDS	None kept.

ITEM	REMARKS
SPILLWAY PLAN SECTIONS DETAILS	See design drawings in Appendix E.
OPERATING EQUIPMENT PLANS & DETAILS	None available.
MISCELLANEOUS	Refer to Section 2. Note: Information presented on this checklist was obtained from DER files; from Mr. Howard Batterman, Camp Akiba Director; and from Mr. Wright Bond, Caretaker for the camp.

APPENDIX C

PHOTOGRAPHS

APPENDIX C
PHOTOGRAPH TABLE OF CONTENTS

FLOW

IMPOUNDMENT

ONE MILE DOWNSTREAM

30"⌀ LOW LEVEL OUTLET

LEGEND

THE LOCATION AND DIRECTION IN WHICH EACH PHOTO WAS TAKEN AND THE NUMBER OF THE PHOTO

200 FEET DOWNSTREAM

1. VIEW OF IMPOUNDMENT WITH TREE COVERED DAM IN THE BACKGROUND. (5/20/81)

2. AN EXAMPLE OF DETERIORATION OF THE UPSTREAM FACE OF THE DAM. (5/20/81)
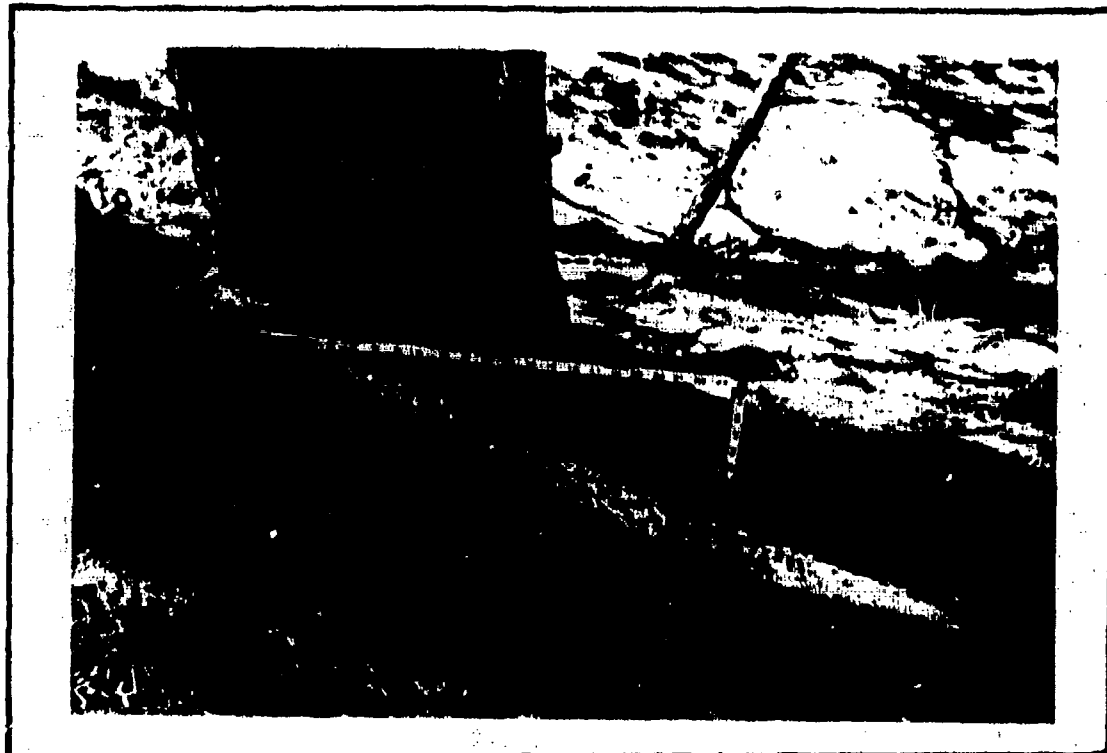
3. AN EXAMPLE OF THE SIZE OF TREES GROWING ON THE DAM. (5/20/81)
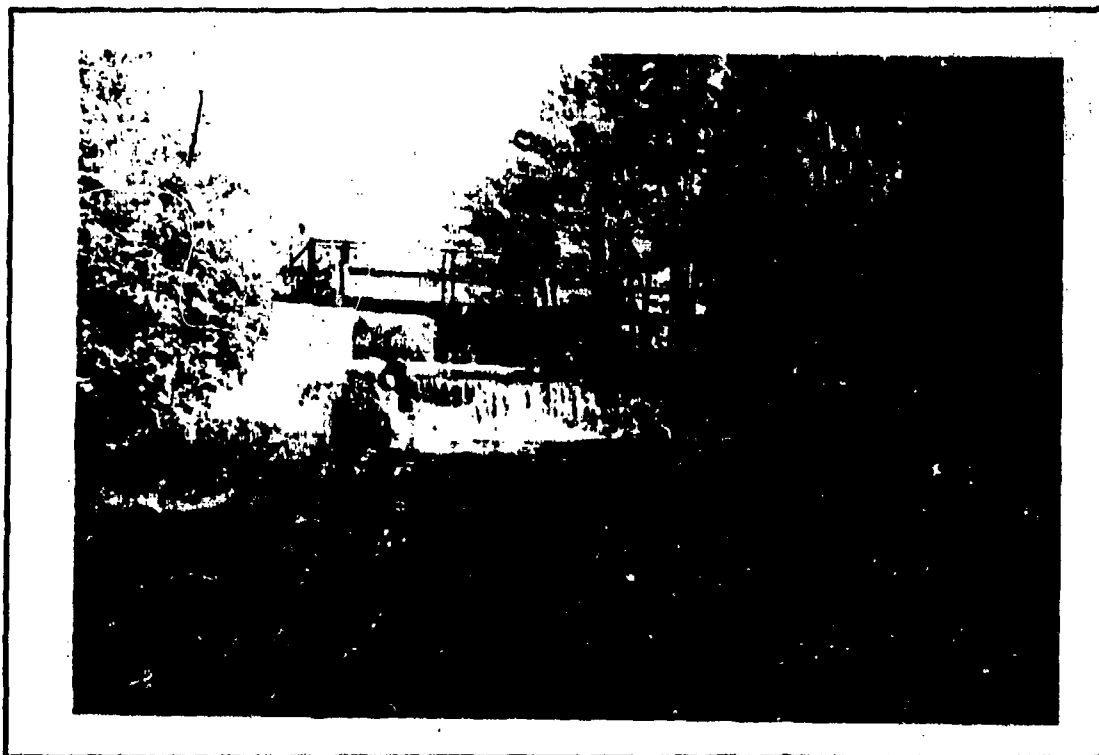
4. LOOKING UPSTREAM OF THE SPILLWAY ADJACENT TO THE RIGHT ABUTMENT OF THE DAM. (5/20/81)

5. DETERIORATED CONCRETE OF THE SPILLWAY OVERFLOW SECTION
   AND LEFT SIDEWALL. (5/20/81)

6. DETAILED VIEW OF THE CONDITION OF THE CONCRETE IN THE
   LEFT SPILLWAY SIDEWALL. (5/20/81)

7. DETERIORATED CONCRETE OF THE SPILLWAY OVERFLOW SECTION AND RIGHT SIDEWALL. (5/20/81)

8. TYPICAL SEEPAGE CONDITIONS AT THE DOWNSTREAM TOE OF THE DAM. (5/20/81)

9. OUTLET OF THE 30-INCH DIAMETER RESERVOIR DRAIN. (5/20/81)

10. DISPLACED SIDEWALL BLOCKS OF THE SPILLWAY DISCHARGE CHANNEL.
(5/20/81)

11. CHANNEL CONDITIONS DOWNSTREAM OF THE SPILLWAY. (5/20/81)

12. POTENTIAL DAMAGE AREA ABOUT ONE MILE DOWNSTREAM OF THE
    DAM. (5/20/81)

13. CAMP AKIBA CAMPERS' QUARTERS POTENTIAL HAZARD AREA 100 TO 200 FEET DOWNSTREAM OF THE DAM. (5/20/81)
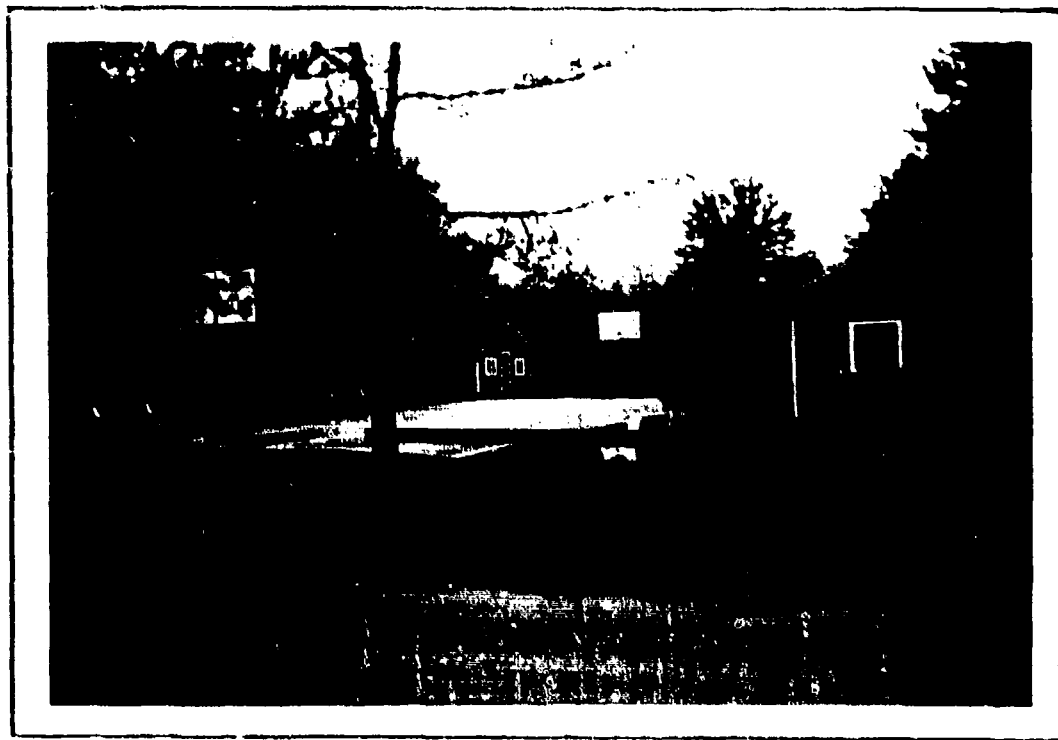
14. CAMP AKIBA CAMPERS' QUARTERS POTENTIAL HAZARD AREA 100 TO 200 FEET DOWNSTREAM OF THE DAM. (5/20/81)

APPENDIX D

HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

LAKE AKIBA
HYDROLOGIC & HYDRAULIC
ENGINEERING DATA

TABLE OF CONTENTS

Sheet No.

CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 3.4 sq. mi., primarily forested

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): El. 942 (126 acre-feet)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): NA

ELEVATION MAXIMUM DESIGN POOL: _____

ELEVATION TOP DAM: El. 946.0

SPILLWAY

    a. Elevation El. 941.8, Notch El. 941.6

    b. Type Concrete Ogee Section

    c. Width NA

    d. Length 50 feet

    e. Location Spillover East Side Abutment

    f. Number and Type of Gates None

OUTLET WORKS: 30-inch diameter low level outlet with assumed low and mid level intakes (12-inch)

    a. Type

    b. Location Approx. 130 Feet East of West Side Abutment.

    c. Entrance inverts Unknown

    d. Exit invert El. 924.±

    e. Emergency draindown facilities 12-inch gate valves

HYDROMETEOROLOGICAL GAGES:

    a. Type None

    b. Location NA

    c. Records NA

MAXIMUM NON-DAMAGING DISCHARGE: Not determined

HEC-1, REVISED
FLOOD HYDROGRAPH PACKAGE

The original "Flood Hydrograph Package" (HEC-1), developed by the Hydrologic Engineering Center, Corps of Engineers, has been modified for use under the National Dam Inspection Program. The "Flood Hydrograph Package (HEC-1), Dam Safety Version", hereinafter referred to as, HEC-1, Rev., has been modified to require less detailed input and to include a dam breach analysis. The required input is obtained from the field inspection of a dam, any available design/evaluation data, relatively simple hydraulic calculations, or information from the USGS Quandrangle maps. The input format is flexible in order to reflect any unique characteristics of an individual dam.

HEC-1, Rev. computes a reservoir inflow hydrograph based on individual watershed characteristics such as: area, percentage of impervious surface area, watershed shape, and hydrograph characteristics determined from regional correlation studies by the Corps of Engineers, Baltimore District. The inflow is routed through the reservoir using spillway discharge data obtained from the field inspection or design data. Flood storage capacity is determined from USGS maps or design information and verified by the field inspection. In the event a spillway cannot discharge 0.5 PMF without overtopping and failure of the dam, downstream channel characteristics obtained from the field inspection and USGS maps are inputed and flows are routed downstream to the damage center and a dam breach analysis is performed 1/

Included in this Appendix are the HEC-1, Rev. pertinent input values and a summary print-out.

1/ "High "hazard structures only

SUBJECT	SHEET	BY	DATE	JOB NO.
Lake Akiba Dam	3	JB	4/10/81	1841-014

Hydrology calcs

Drainage Area (Planimetered from USGS Quad. Sh.) = 3.40 mi^2

Surface Area

El.	Area (Acres)
928	0
942	27
960	84

PMP Calcs. (HMR 33)

Area is in Zone 6
24 hr., 200 mi^2 rainfall = 22.4"

Hr.	%	Rainfall (in)	Δ Rainfall (in.)
6	113	25.3	25.3
12	123	27.6	2.3
24	132	29.6	2.0
48	142	31.8	2.2

Snyder Coefficients (Information provided by Balt. COE)

Area is in Zone 1

$$C_p = 0.45, \quad C_t = 1.23$$

$$T_p = C_t (L \cdot L_{CA})^{0.3}$$

$$L \approx 4.7 \text{ mi}, \quad L_{CA} \approx 2.8 \text{ mi}$$

$$T_p = 1.23 (4.7 \times 2.8)^{0.3}$$

$$T_p = 2.66 \text{ hr.}$$

Stage - Discharge Calculations :

1.) Flow over spillway was calculated according to the weir flow formula → $Q_S = C L_S H_S^{3/2}$, where $C \approx 3.3$ for ogee section and $L_S = 50$ feet.

2.) Flow over dam was also calculated according to the weir formula → $Q_D = C L_D H_D^{3/2}$, where $C \approx 3.0$ for short broad-crested weir (assumes trees are removed from dam)

3.) Because the capacity of the outlet works is negligible compared to the SDF discharge, the stage-discharge table and curve will not consider its contribution to the available discharge.

Stage - Discharge Table : (Top of dam El. 946.0)

Elev.* (MSL)	H_S (feet)	Q_S (cfs)	H_D (feet)	L_D (feet)	Q_D (cfs)	Q_{total} (cfs)
942.	0	0	—	—	—	0
943.	1.0	165	—	—	—	165
944.	2.0	467	—	—	—	467
945.	3.0	857	—	—	—	857
946.	4.0	1,320	0	0	0	1,320
947.	5.0	1,845	1.0	312	936	2,781
948.	6.0	2,425	2.0	318	2,698	5,123
949.	7.0	3,056	3.0	325	5,066	8,122
950.	8.0	3,734	4.0	340	8,160	11,894

Stage vs. Discharge

Top of Dam
El. 946.0

Spillway Crest
El. 942.0

Discharge (cfs)

6,000 — 5,000 — 4,000 — 3,000 — 2,000 — 1,000

950

948

946

944

942

Elevation (feet - MSL)
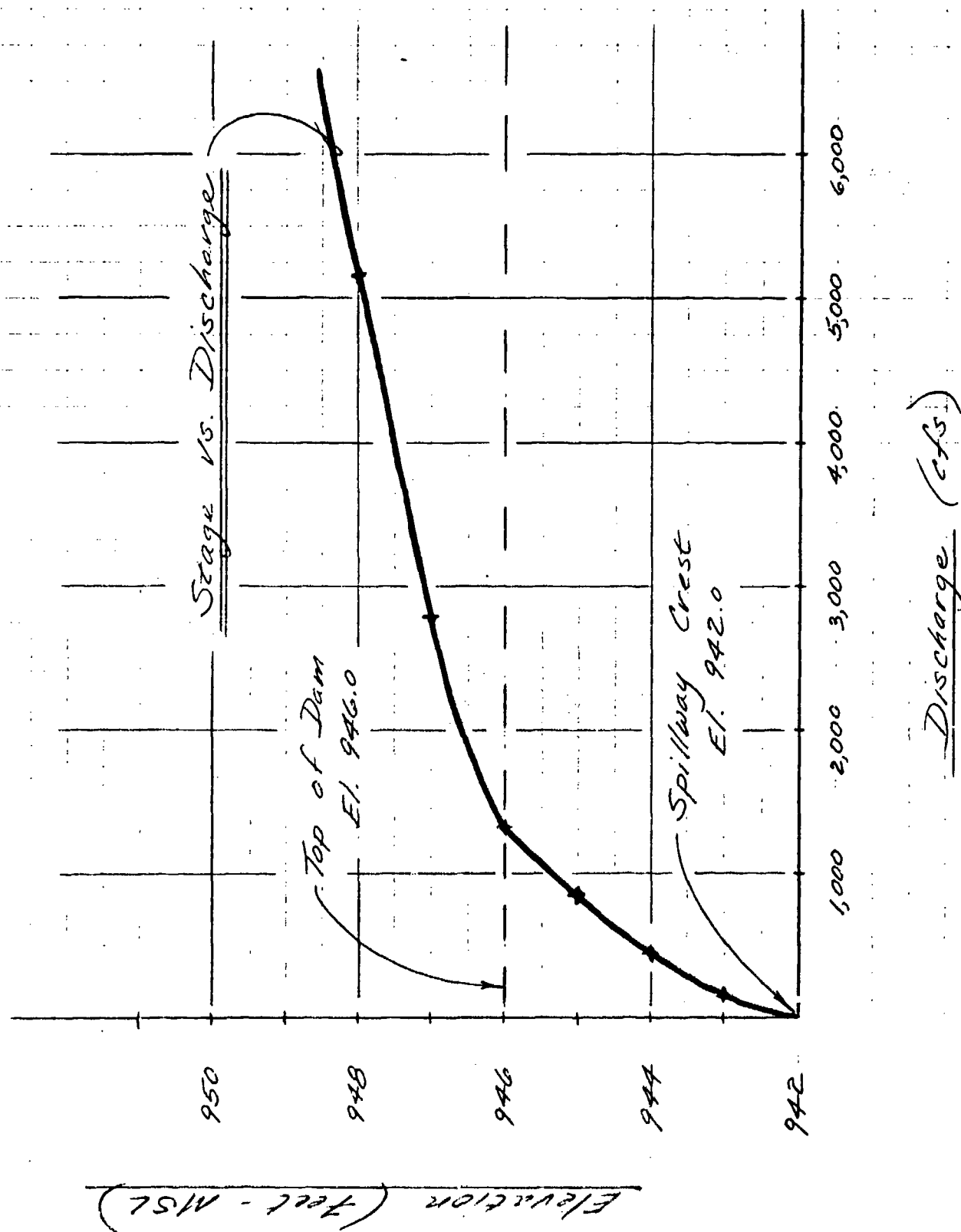
Note: Flow in 30-inch low level outlet was not considered in constructing this discharge curve.

SUBJECT	SHEET	BY	DATE	JOB NO
Lake Akiba Dam	6	ADH	6/23/81	1841.014

√ ℒ 7/6/81

Downstream Routing Information:

The existing spillway capacity is not adequate to pass the flow anticipated during a ½ PMF event. Therefore, a breach analysis of the dam was performed to determine the extent of flooding in the primary hazard areas. The breach was assumed to occur when the water surface reached el. 947, or at the point where the dam was overtopped by one foot. This hypothetical breach was assumed to develop gradually over a one hour period, with a base width of 150 feet and side slopes of 2H:1V. The following cross sections are approximate only due to the nature of the terrain and the extent of the Phase I investigation:
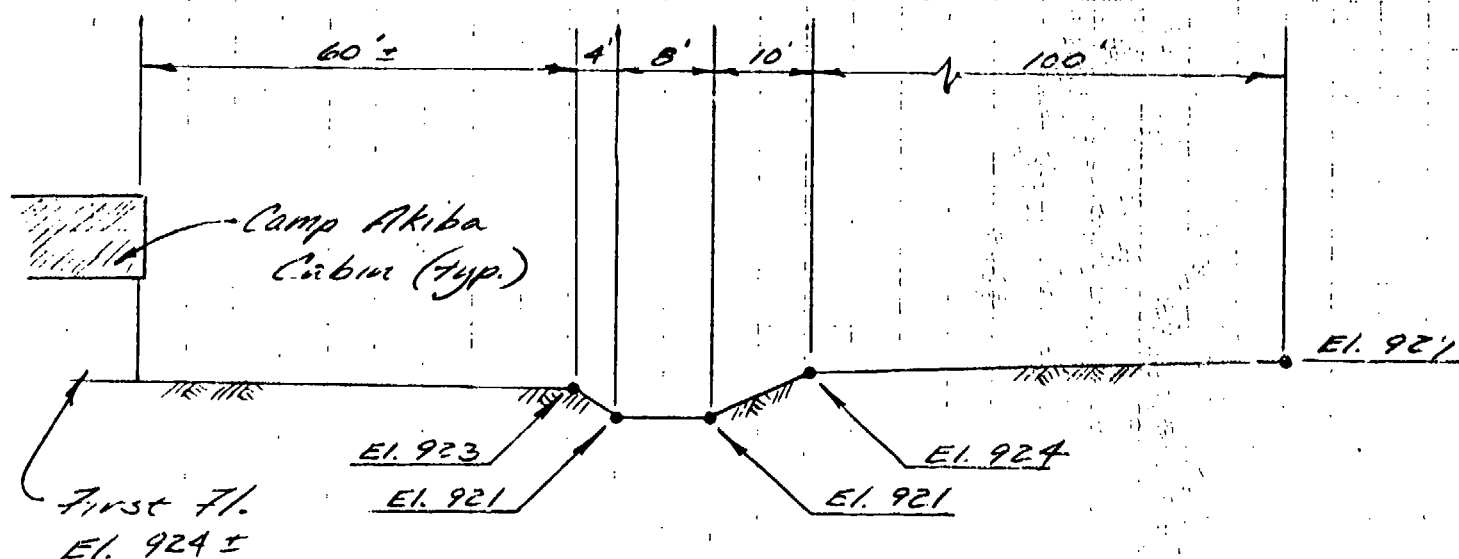
Hazard Area - DS-1 (looking d/s)
(approximately 100 feet d/s)

NTS

SUBJECT		SHEET	BY	DATE	JOB NO
Lake Akiba Dam		7	ADH	6/23/81	1841.014

VE 7/7/81
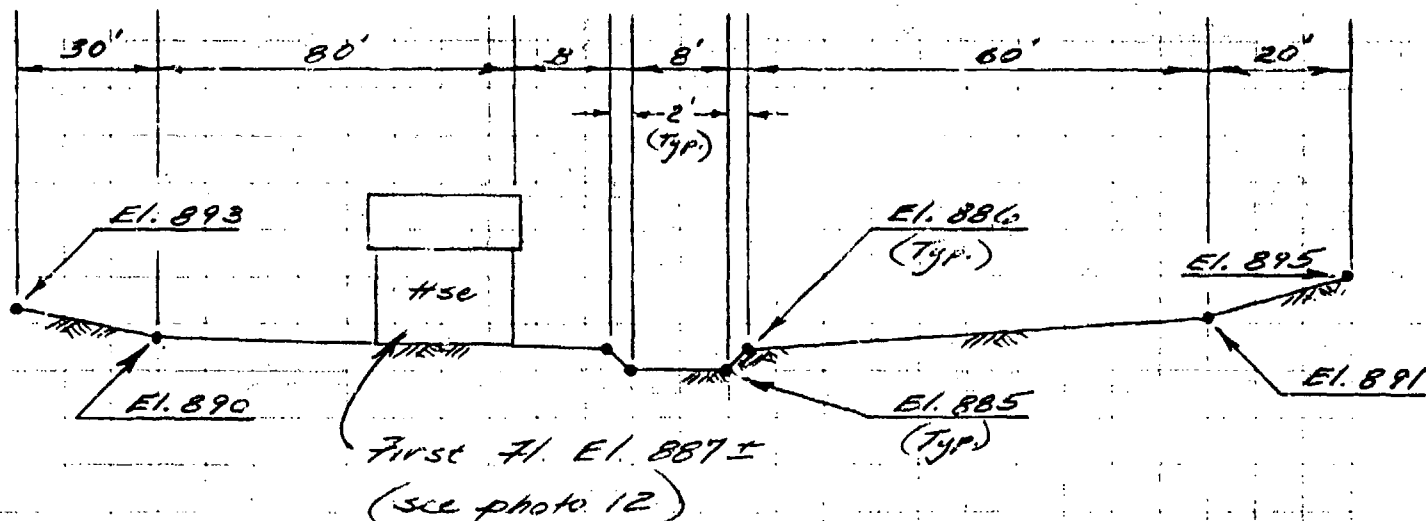
Hazard Area – DS-2 (looking d/s)

(approximately 1 mile d/s of dam)   NTS

```
***************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION    JULY 1978
   LAST MODIFICATION  01 APR 80
***************************
```

```
 1   A1
 2   A2
 3   A3
 4   B    300   0    10   0    0    0    0    0    -4   0
 5   B1   5
 6   J    1     9    1
 7   J1   .1    .2   .3   .4   .5   .6   .7   .8   1.0
 8   K    0     INFLOW
```

NATIONAL DAM INSPECTION PROGRAM
BALTIMORE CORPS OF ENGINEERS
        LAKE AKIBA DAM

```
 9   K1                RUNOFF TO LANE AKIBA
10   M    1     3.4
11   P    0     22.4  113  123  132  142       1
12   T
13   W    2.7   0.45
14   X   -1.5  -0.05
15   K    1     OUTFLO
```

OUTFLOW FROM LANE AKIBA

```
16   K1                     1    1    1    1         0.05
17   Y
18   Y1   1
19   Y4   942   943  944  945  946  947  948  949  950
20   Y5   0     165  467  857  1320 2781 5123 8122 11894
21   $A   0     27   84
22   $E   928
23   $$   942
24   $0   946   942  960
25   K    99
```

 1   PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

```
RUNOFF HYDROGRAPH AT        INFLOW
ROUTE HYDROGRAPH TO         OUTFLO
END OF NETWORK
```

```
***************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION    JULY 1978
   LAST MODIFICATION  01 APR 80
***************************
```

RUN DATE* 81/06/19.
    TIME* 11.29.17.

NATIONAL DAM INSPECTION PROGRAM
BALTIMORE CORPS OF ENGINEERS
        LAKE AKIBA DAM

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
300	0	10	0	0	0	0	0	-4	0

JOPER	NWT	LRDPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 9 LRTIO= 1

```
RTIOS=  .10  .20  .30  .40  .50  .60  .70  .80  1.00
```

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

RUNOFF TO LAKE AKIBA

	ISTAQ INFLOW	ICOMP	IECON	ITAPE	JPLT	INAME	ISTAGE	IAUTO
		0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSFC	RATIO	ISNOW	ISAME	LOCAL
1	1	3.40	0.00	3.40	0.00	0.000	0	1	0

PRECIP DATA

SFFE	PHS	R6	R12	R24	R48	R72	R96
0.00	22.40	113.00	123.00	132.00	142.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .800

LOSS DATA

LRDPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.05	0.00	0.00

UNIT HYDROGRAPH DATA

$TP = 2.70$ $CP = .45$ $NTA = 0$

RECESSION DATA

$STRTQ = -1.50$ $QRCSN = -.05$ $RTIOR = 2.00$

UNIT HYDROGRAPHl00 END-OF-PERIOD ORDINATES, $LAG = 2.71$ HOURS, $CP = .45$ $VOL = .97$

5.	20.	41.	66.	95.	126.	160.	195.	231.	266.
296.	322.	344.	361.	372.	378.	376.	365.	351.	337.
324.	312.	300.	288.	277.	267.	256.	247.	237.	228.
219.	211.	203.	195.	187.	180.	173.	167.	160.	154.
148.	143.	137.	132.	127.	122.	117.	113.	108.	104.
100.	96.	93.	89.	86.	82.	79.	76.	73.	71.
68.	65.	63.	60.	58.	56.	54.	52.	50.	48.
46.	44.	42.	41.	39.	38.	36.	35.	34.	32.
31.	30.	29.	28.	27.	26.	25.	24.	23.	22.
21.	20.	19.	19.	18.	17.	17.	16.	15.	15.

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q

SUM 25.45 23.05 2.40 268116.
(646.)(585.)(61.)(7592.20)

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

OUTFLOW FROM LAKE AKIBA

	ISTAQ OUTFLO	ICOMP	IECON	ITAPE	JPLT	INAME	ISTAGE	IAUTO
		1	0	0	0	0	1	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT

STAGE	942.00	943.00	944.00	945.00	946.00	947.00	948.00	949.00	950.00
FLOW	0.00	165.00	467.00	857.00	1320.00	2781.00	5123.00	8122.00	11894.00

SURFACE AREA=	0.	27.	84.
CAPACITY=	0.	126.	1078.
ELEVATION=	928.	942.	960.

CREL	SFWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
942.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOFEL	COQD	EXPD	DAMWID
946.0	0.0	0.0	0.

PEAK OUTFLOW IS 527. AT TIME 43.67 HOURS

PEAK OUTFLOW IS 1081. AT TIME 43.50 HOURS

PEAK OUTFLOW IS 1719. AT TIME 42.83 HOURS

PEAK OUTFLOW IS 2307. AT TIME 42.83 HOURS

PEAK OUTFLOW IS 2902. AT TIME 42.67 HOURS

PEAK OUTFLOW IS 3488. AT TIME 42.67 HOURS

PEAK OUTFLOW IS 4069. AT TIME 42.67 HOURS

PEAK OUTFLOW IS 4649. AT TIME 42.67 HOURS

PEAK OUTFLOW IS 5823. AT TIME 42.50 HOURS

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

OPERATION	STATION	AREA	PLAN	RATIO 1 .10	RATIO 2 .20	RATIO 3 .30	RATIO 4 .40	RATIO 5 .50	RATIO 6 .60	RATIO 7 .70	RATIO 8 .80	RATIO 9 1.00
HYDROGRAPH AT	INFLOW	3.40	1	585.	1170.	1755.	2340.	2925.	3509.	4094.	4679.	5849.
		(8.81)		(16.56)(	33.13)(	49.69)(	66.25)(	82.81)(	99.38)(	115.94)(	132.50)(	165.63)
ROUTED TO	OUTFLO	3.40	1	527.	1081.	1719.	2307.	2902.	3488.	4069.	4649.	5823.
		(8.81)		(14.94)(	30.61)(	48.68)(	65.33)(	82.16)(	98.76)(	115.22)(	131.66)(	164.89)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	942.00	942.00	946.00
STORAGE	126.	126.	253.
OUTFLOW	0.	0.	1320.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	944.16	0.00	190.	527.	0.00	43.67	0.00
.20	945.48	0.00	235.	1081.	0.00	43.50	0.00
.30	946.27	.27	264.	1719.	3.00	42.83	0.00
.40	946.68	.68	279.	2307.	5.17	42.83	0.00
.50	947.05	1.05	294.	2902.	6.67	42.67	0.00
.60	947.30	1.30	304.	3488.	7.83	42.67	0.00
.70	947.55	1.55	314.	4069.	9.00	42.67	0.00
.80	947.80	1.80	324.	4649.	9.67	42.67	0.00
1.00	948.23	2.23	343.	5823.	10.83	42.50	0.00

EOI ENCOUNTERED.
C>BYE
JOB PROCESSING CCUS   2.803
BYE 81/06/19. 13.07.59.

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```
1*******************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION    JULY 1978
LAST MODIFICATION   01 APR 80
*******************************
```

NATIONAL DAM INSPECTION PROGRAM
BALTIMORE CORPS OF ENGINEERS
LAKE AKIBA DAM BREACH

```
 1    A1
 2    A2
 3    A3
 4    B   300   0                                        0    0    0    0    0    0    -4    0
 5    B1  5
 6    J   2     1                                        1    1
 7    J1  .5
 8    K   0   INFLOW
 9    K1                                                 1
10    M   1     1                                        1
```

RUNOFF TO LAKE AKIBA

```
11    P   0   22.4   3.4   113   123   132   142
12    T
13    W   2.7  0.45
14    X   -1.5 -0.05  0.05
15    K   1   OUTFLO
16    K1                                                 1
```

OUTFLOW FROM LAKE AKIBA

```
17    Y
18    Y1  1
19    Y4  942  943  944  945  946  947  948  949  950
20    Y5  0    165  467  857  1320 2781 5123 8122 11894
21    $A  0    27   84
22    $E  928  942  960
23    $$  942
24    $D  946
25    $B  150  928  1.0  942  1.0  960  947  -1   949
26    $B  150  928  1.0  942  1.0  960  947
27    K   1   DS-1
28    K1                                                 1
```

CHANNEL ROUTING TO DS-1

```
29    Y
30    Y1  1
31    Y6  .03  .04  .04
32    Y7  0    928  921  927  100  150
33    Y7  162  921  924  286
34    K   1   DS-2
35    K1                                                 1
```

CHANNEL ROUTING TO DS-2

```
36    Y
37    Y1  1
38    Y6  .05  .06  .007
39    Y7  0    893  885  890  886  120
40    Y7  130  886  891  210
41    K   99
```

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

```
      RUNOFF HYDROGRAPH AT          INFLOW
      ROUTE HYDROGRAPH TO           OUTFLO
      ROUTE HYDROGRAPH TO           DS-1
      ROUTE HYDROGRAPH TO           DS-2
      END OF NETWORK
```

elev. 967.0

El. 942.0 *

El. 968.0

Top of Dam El. 946.0

El. 946.0

150'

1/2   1/2

* Starting water surface elevation

__Dam Breach statement__

The portion of the dam assumed to be breached is based on the geometry of the site. The depth at which flow over the top of the dam at which failure is initiated and the elapsed time to complete failure are based on the general appearance and type of the structure. Considerations used in the Corps of Engineers publication "Basic Concepts of Dam Breach and Development of Dam Break Hydrographs."

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NATIONAL DAM INSPECTION PROGRAM
BALTIMORE CORPS OF ENGINEERS
LAKE AKIBA DAM BREACH

JOB SPECIFICATION

NQ	NHR	NHIN	IDAY	IHR	IMIN	.METRC	IPLT	IPRT	NSTAN
300	0	10	0	0	0	0	0	-4	0

JOFER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 2 NRTIO= 1 LRTIO= 1

RTIOS= .50

SUB-AREA RUNOFF COMPUTATION

RUNOFF TO LAKE AKIBA

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JFRT	INAME	ISTAGE	IAUTO
INFLOW	0	0	0	0	0	1	0	0

TRSPC COMPUTED BY THE PROGRAM IS .800

SFFE	FMS	R6	R12	R24	R48	R72	R96
0.00	22.40	113.00	123.00	132.00	142.00	0.00	0.00

PRECIP DATA

HYDROGRAPH DATA

IHYDG	IUHG	TAKEA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	3.40	0.00	3.40	0.00	0.000	0	1	0

LOSS DATA

LROPT	STRKK	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.05	0.00	0.00

UNIT HYDROGRAPH DATA
TP= 2.70   CP= .45   NTA= 0

RECESSION DATA
STRTQ= -1.50   QRCSN= -.05   RTIOK= 2.00

UNIT HYDROGRAPH100 END-OF-PERIOD ORDINATES, LAG= 2.71 HOURS, CP= .45   VOL= .97

5.	20.	41.	66.	95.	126.	160.	195.	231.	266.
296.	322.	344.	361.	372.	378.	376.	365.	351.	337.
324.	312.	300.	288.	277.	267.	256.	247.	237.	228.
219.	211.	203.	195.	187.	180.	173.	167.	160.	154.
148.	143.	137.	132.	127.	122.	117.	113.	108.	104.
100.	96.	93.	89.	86.	82.	79.	76.	73.	71.
68.	65.	63.	60.	58.	56.	54.	52.	50.	48.
46.	44.	42.	41.	39.	38.	36.	35.	34.	32.
31.	30.	29.	28.	27.	26.	25.	24.	23.	22.
21.	20.	19.	19.	18.	17.	17.	16.	15.	15.

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q

SUM   25.45   23.05   2.40   268116.
(646.)(585.)(41.)(7547.20)

HYDROGRAPH ROUTING

OUTFLOW FROM LAKE AKIBA

	ISTAQ OUTFLO	ICOMP	IECON	ITAPE	JPLT	JFRT	INAME	ISTAGE	IAUTO
		1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

IRES	ISAME	IOPT	X
1	1	0	0.000

					IPMP		LSTR
					0		0

NSTPS	NSTDL	LAG	AMSKK	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	-942.	-1

	QLOSS	CLOSS	AVG
	0.0	0.000	0.00

STAGE	942.00	943.00	944.00	945.00	946.00	947.00	948.00	949.00	950.00
FLOW	0.00	165.00	467.00	857.00	1320.00	2781.00	5123.00	8122.00	11894.00

SURFACE AREA=	0.	27.	84.
CAPACITY=	0.	126.	1078.
ELEVATION=	928.	942.	960.

CREL	SPWID	COOW	EXPW	ELEVL	COOL	CAREA	EXPL
942.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COOD	EXPD	DAMWID
946.0	0.0	0.0	0.

DAM BREACH DATA

	Z	ELBM	TFAIL	WSEL	FAILEL
BRWID 150.	2.00	928.00	1.00	942.00	960.00

DAM BREACH DATA

	Z	ELBM	TFAIL	WSEL	FAILEL
BRWID 150.	2.00	928.00	1.00	942.00	947.00

PEAK OUTFLOW IS   2902. AT TIME   42.67 HOURS

BEGIN DAM FAILURE AT 42.33 HOURS

PEAK OUTFLOW IS   9743. AT TIME   43.08 HOURS

HYDROGRAPH ROUTING

CHANNEL ROUTING TO DS-1

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
DS-1	1	0	0	0	0	0	0	0

ALL PLANS HAVE SAME ROUTING DATA

	IRES	ISAME	IOPT	IPMP	LSTR
	1	1	0	0	0

QLOSS	CLOSS	AVG			
0.0	0.000	0.00			

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	0.	0

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0300	.0400	.0400	921.0	927.0	100.	.04000

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC
```
  0.00  928.00   40.00  927.00   90.00  924.00  150.00  923.00  154.00  921.00
162.00  921.00  172.00  924.00  286.00  928.00
```

STORAGE	0.00	0.00	.01	.02	.03	.04	.06	.07	.10	.15
	.21	.28	.36	.45	.55	.66	.78	.91	1.06	1.21
OUTFLOW	0.00	0.00	30.45	62.70	105.99	160.71	227.40	234.80	309.68	457.29
	688.56	1037.25	1489.89	2047.66	2716.32	3502.63	4413.57	5456.09	6637.05	7963.15
STAGE	921.00	921.32	921.63	921.95	922.26	922.58	922.89	923.21	923.53	923.84
	924.16	924.47	924.79	925.11	925.42	925.74	926.05	926.37	926.68	927.00
FLOW	0.00	0.00	30.45	62.70	105.99	160.71	227.40	234.80	309.68	457.29
	688.56	1037.25	1489.89	2047.66	2716.32	3502.63	4413.57	5456.09	6637.05	7963.15

MAXIMUM STAGE IS 925.5

MAXIMUM STAGE IS 927.3

NORMAL DEPTH CHANNEL ROUTING

HYDROGRAPH ROUTING

CHANNEL ROUTING TO DS-2

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
DS-2	1	0	0	0	0	0	0	0

ALL PLANS HAVE SAME ROUTING DATA

	IRES	ISAME	IOPT	IPMP	LSTR
	1	1	0	0	0

QLOSS	CLOSS	AVG			
0.0	0.000	0.00			

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0500	.0400	.0600	885.0	895.0	5000.	.00700

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC
0.00 873.00 30.00 890.00 118.00 886.00 120.00 885.00 128.00 885.00
130.00 886.00 190.00 .0600 891.00 210.00 895.00

STORAGE	0.00	.55	1.23	2.60	5.05	8.59	13.21	18.90	25.68	33.54
	42.44	52.08	62.38	73.17	84.44	96.19	108.32	120.61	133.05	145.66
OUTFLOW	0.00	8.85	29.80	70.64	142.64	256.55	421.52	645.83	937.17	1302.78
	1765.60	2327.28	2986.30	3737.64	4572.32	5491.06	6569.48	7752.92	9021.16	10372.69
STAGE	885.00	885.53	886.05	886.58	887.11	887.63	888.16	888.68	889.21	889.74
	890.26	890.79	891.32	891.84	892.37	892.89	893.42	893.95	894.47	895.00
FLOW	0.00	8.85	29.80	70.64	142.64	256.55	421.52	645.83	937.17	1302.78
	1765.60	2327.28	2986.30	3737.64	4572.32	5491.06	6569.48	7752.92	9021.16	10372.69

MAXIMUM STAGE IS 891.2

MAXIMUM STAGE IS 894.4

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

OPERATION	STATION	AREA	PLAN	RATIO 1
				.50
HYDROGRAPH AT	INFLOW	3.40	1	2925.
		(8.81)	(	82.81)(
			2	2925.
			(	82.81)(
ROUTED TO	OUTFLO	3.40	1	2902.
		(8.81)	(	82.16)(
			2	9339.
			(	264.46)(
ROUTED TO	DS-1	3.40	1	2902.
		(8.81)	(	82.18)(
			2	9330.
			(	264.19)(
ROUTED TO	DS-2	3.40	1	2886.
		(8.81)	(	81.73)(
			2	8936.
			(	)(

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SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	ELEVATION STORAGE OUTFLOW	INITIAL VALUE 942.00 126. 0.	SPILLWAY CREST 942.00 126. 0.	TOP OF DAM 946.00 253. 1320.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	947.05	1.05	294.	2902.	6.67	42.67	0.00

PLAN 2 ....

	ELEVATION STORAGE OUTFLOW	INITIAL VALUE 942.00 126. 0.	SPILLWAY CREST 942.00 126. 0.	TOP OF DAM 946.00 253. 1320.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	947.03	1.03	293.	9743.	2.25	43.08	42.33

PLAN 1   STATION DS-1

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	2902.	925.5	42.67

PLAN 2   STATION DS-1

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	9330.	927.3	43.00

PLAN 1   STATION DS-2

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	2886.	891.2	42.83

PLAN 2   STATION DS-2

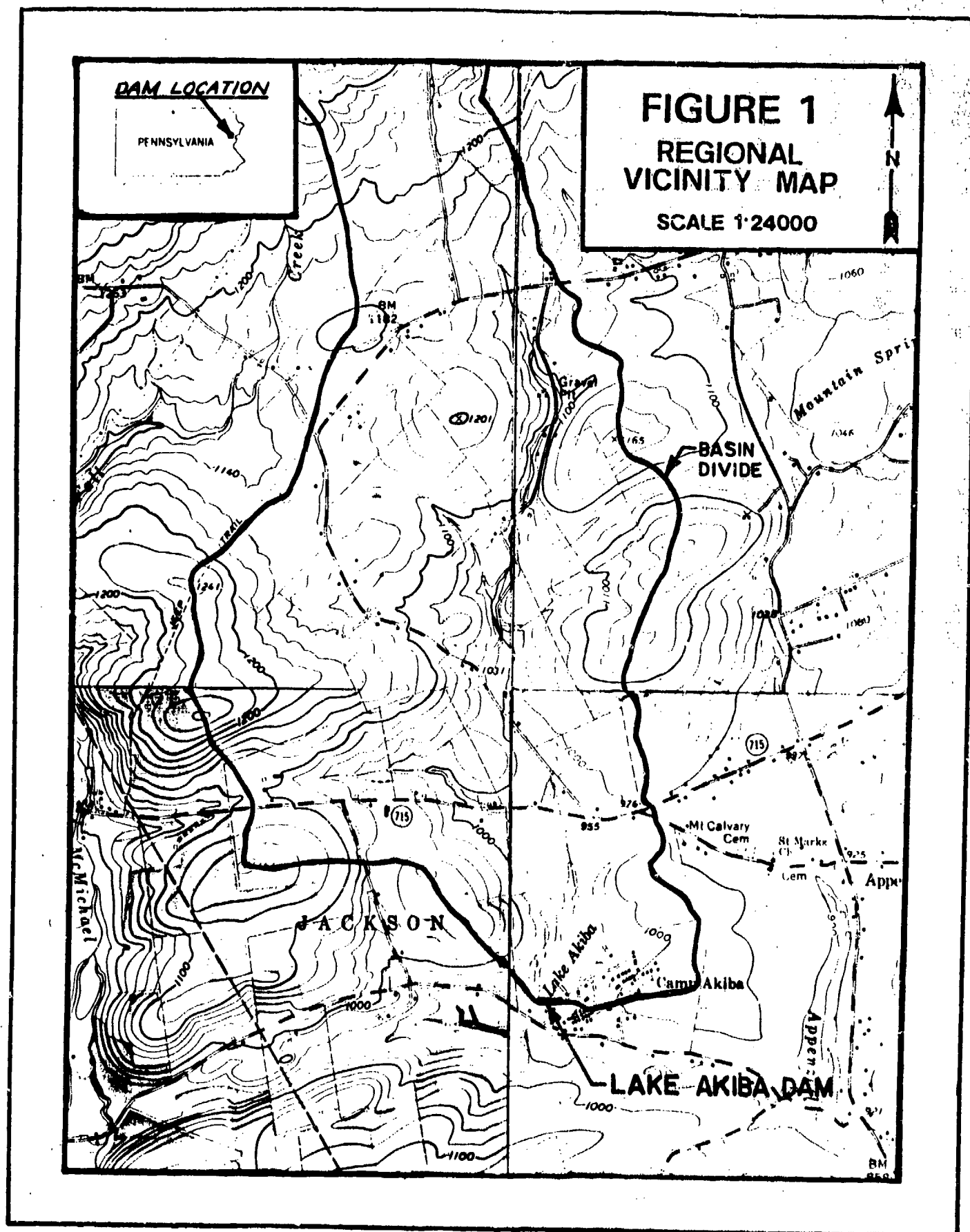| RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	9735.	924.4	43.17

APPENDIX E

REGIONAL VICINITY MAP
&
DRAWINGS

APPENDIX E

REGIONAL VICINITY MAP & DRAWINGS

TABLE OF CONTENTS

FIGURE 1
REGIONAL VICINITY MAP
SCALE 1:24000

DAM LOCATION
PENNSYLVANIA

BASIN DIVIDE

LAKE AKIBA DAM

LAKE AKIBA DAM

THE CAMP COMPANY, INC.

SHEET 2

LOCATION PLAN
(PROPOSED)
LAKE AKIBA DAM
of
THE CAMP COMPANY, INC.

sheet 3

GENERAL PLAN
PROPOSED
LAKE AKIBA DAM
for
THE CAMP COMPANY

SCALE 1 INCH 200 FT
JOHN F. SEIFERT C.E.
TANNERSVILLE PA.
APRIL 1925

Sheet 4

CROSS SECTION

LAKE AKIBA DAM

or

PROPOSED

THE CAMP COMPANY, INC.

SCALE 1 INCH = 5 Ft.

JOHN T. BEEM, C.E.
TANNERSVILLE, PA.

APRIL 1936

FLOW LINE ELEV. 842 Ft.

12 INCHES PLACED RIPRAP

DROP GATE

SUMP AREA

EARTH FILL OF
GRAVELLY CLAY SOIL

EARTH FILL OF
GRAVELLY CLAY SOIL

ORIGINAL SURFACE

CONCRETE

12 INCHES PLACED RIPRAP

30" REINFORCED CONCRETE (OUTLET PIPE ENCLOSED IN

SECTION B-B

LONGITUDINAL SECTION
PROPOSED
LAKE AHERN DAM
THE CAMP COMPANY INC.
JOHN H. SEMMC
TAYLORSVILLE, PA.

SCALE: Horiz 1" = ... Ft
Vert 1" = 70 Ft

APRIL 1926.
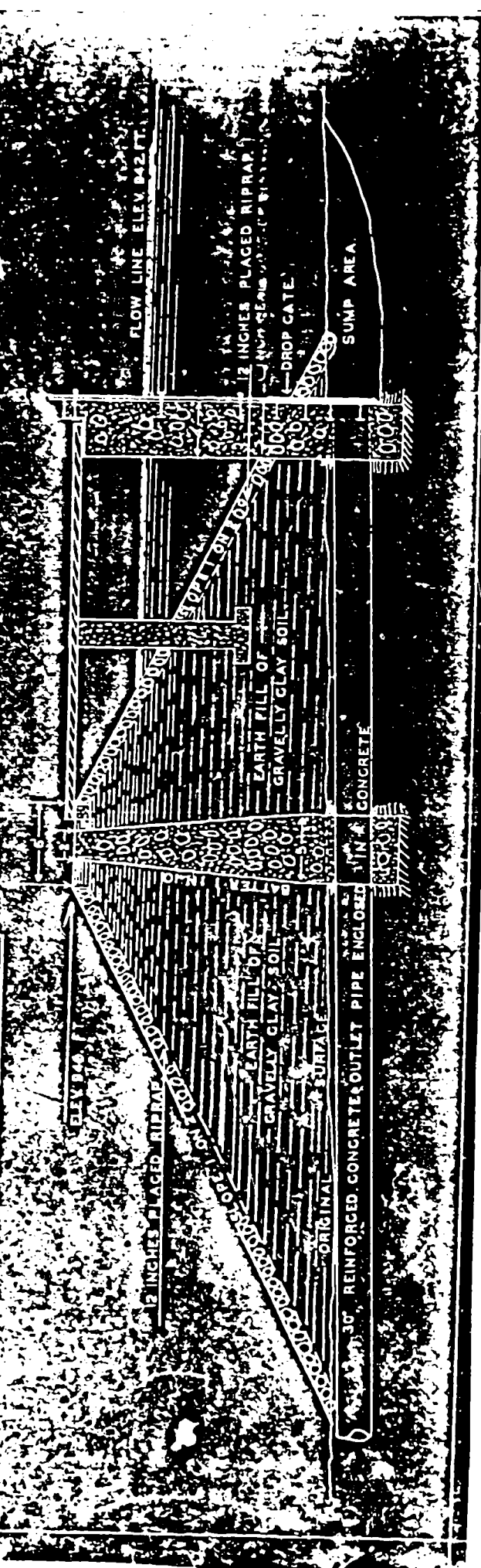
APPENDIX F

GEOLOGY

SITE GEOLOGY

LAKE AKIBA DAM

Lake Akiba Dam is located in Monroe County (PA) within the Pocono Plateau section of the Appalachian Plateaus physiographic province. The site is underlain by gently northwestward dipping beds of the Devonian Catskill group continental type sedimentary rocks. These consist of red to brown and gray shales, siltstones, sandstones and conglomerates varying from a few inches (flagstones) to several feet or more in thickness. Wisconsin epoch glacial deposits of sand and gravel mantle the rock surface and attain considerable thicknesses along valley floors and side slopes. Some swamp deposits occur where depressions or kettles exist as a result of the isolation and decay of ice during the retreat of the last glacial advance into the area.
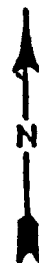
No active structural faults are known to exist in the area.

Well developed jointing and fracturing occur in the bedrock units, particulary in the shales and siltstones. The Catskill rocks yield excellent quality groundwater and the formation is considered a fair to good aquifer. Glacial deposits occurring in the valley floor are quite permeable and act as excellent sources of groundwater and recharge to the underlying Catskill group sedimentary units.

DAM LOCATION

PENNSYLVANIA

BORDER OF WISCONSIN DRIFT

FIGURE 1
REGIONAL
GEOLOGY MAP
SCALE 1:24000

N

CATSKILL FORMATION Dck

JACKSON

LAKE AKIBA DAM

Camp Akiba

Mt Calvary Cem
St Marks Ch
Cem
Appenz